# Water Supply Engineering

Chapter 1

## Introduction

Lecture 1 (Week 1)

**Introduction, Importance of water, Definition of types of water, Historical development of water supply system, Objectives of water supply system, Schematic diagram and Components of water supply system**

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## Learning Objectives

- Realize the significance of water in human life and nature.
- Differentiate between various types of water based on purity and application.
- Explain the history of water supply systems from ancient to contemporary periods.
- Understand the major developments in water supply and treatment.
- To know the main functions of a water supply system and its component.

# 1.Introduction

## Water Supply Engineering

Water Supply Engineering is a branch of civil engineering that encompasses the planning, designing, construction, operation, and maintenance of water supply systems. It enables the provision of safe, clean, and adequate water for domestic, industrial, agricultural, and commercial use.

## 1.1 Importance of water

- Human Survival
- Agriculture
- Industry
- Sanitation and Hygiene
- Ecological Balance: Water bodies such as rivers, lakes, and oceans provide habitats for aquatic organisms. These ecosystems play a significant role in maintaining biodiversity and supporting the food chain.

**Other Use Of water**

- Drinking and Cooking
- Washing their body, clothes and utensils
- Keeping house and communities clean
- Recreational purposes
- Watering the plants and municipal facilities
- Irrigation in farms
- Hydropower generation and navigation

## 1.2 Definition of types of water

### 1.2.1 Pure and impure water

**Pure water**

- Water that doesn't contain any other substances than hydrogen and oxygen is called pure water.
- Pure water is not suitable for drinking purposes as it lacks several nutrients required for human body.
- It is not found in natural state and is prepared chemically in laboratories.
- Widespread use in medical and laboratory purposes.

(Kansakar, 2015)

*Figure 1: Pure Water(Source: (Wikipedia, n.d.)*

**Impure water**

- The water that contains substances other than hydrogen and oxygen is called impure water.
- Major impurities are minerals, salts, gases and micro-organisms.

- Water used for drinking purposes is impure water, but the impurities should not exceed a certain limit.
- All-natural water is impure.

### 1.2.2 Potable and wholesome water

**Potable water**

- Water that is safe for drinking by humans and animals is known as potable water.
- Must be free from microorganisms and chemicals.
- Pristine (without contaminate) springs are natural source of potable water and they are generally prepared after several treatments.

**Wholesome water**

- Water that is colorless, odorless, clear, palatable (good taste) and free from any chemical salts and microorganisms is called wholesome water.
- Must be free from all kinds of poisonous substances and fecal contamination.
- It is fit for drinking, cooking or washing without any potential harms.

### 1.2.3 Polluted and contaminated water

**Polluted water**

- Water that contains excessive impurities such as minerals, salts, gases, microorganisms, etc. is called polluted water.
- Not clean and should not be used for drinking, cleaning or any other purposes at all.

*Figure 2: Polluted Water( Source (Source: https://www.nrdc.org/stories/water-pollution-everything-you-need-know, n.d.)*

- Water becomes polluted due to
- releases of toxins and industrial wastes in the water sources.

**Contaminated water**

- Water that contains microorganisms such as bacteria, viruses, protozoa, worms,etc. is called contaminated water.
- It may look clean but contains microorganisms not visible to naked eye.
- Water becomes contaminated due to fecal deposition and growth of unwanted vegetation.

## 1.3 Historical development of water supply system

- The earliest civilization was all based near water sources, as water is an indispensable need for development of settlement.
- The earliest form of proper water supply system can be seen in the ancient city of Mohenjo-Daro (Indus civilization) in

the form of water supply to the public bathhouse. Brick lined wells were also built.

- They also had rock lined passage way for water and sewages.

**Water supply systems have evolved significantly over time:**

• Ancient Civilizations: Indus Valley, Mesopotamia, and Egypt developed wells, aqueducts, and canals to distribute water.

• Roman Era: The Romans built extensive aqueducts and underground piping systems for public baths and drinking water.

• Medieval Period: Water supply relied on wells and local reservoirs with limited treatment methods.

• Industrial Revolution: With urbanization, pipelines, treatment plants, and pumping stations were introduced.

• Modern Times: Advanced filtration, chlorination, desalination, and recycling techniques ensure safe and efficient water distribution.

The development of water supply systems in Nepal can be categorized into different historical periods: **Ancient, Medieval, Modern, and Contemporary Eras**.

## 1. Ancient Water Supply Systems (Pre-15th Century)

In ancient Nepal, especially in the **Kathmandu Valley**, the water supply system was well-planned and sustainable. The Lichhavi and Malla rulers focused on **natural springs, stone spouts, wells, and ponds** to provide water to the growing population.

- **Dhunge Dhara (Stone Spouts)**:
- These were built to channel underground water to public areas.

*Figure 3:Dhunge Dhara*

Many ancient **hitis (water spouts)** from this period are still functional today.

- **Rajkulo (Royal Canals)**: These canals were constructed to supply water from rivers to farmlands and settlements. One famous example is the **Budhanilkantha Rajkulo**, built to irrigate fields.
- **Wells and Ponds**: Wells (kuwa) and large ponds (pukhu) were commonly used for daily water needs. **Rani Pokhari** in Kathmandu is a historical pond from this era.

The ancient water systems were **community-managed**.

## 2. Medieval Water Supply Systems (15th - 18th Century)

During the **Malla period**, water supply infrastructure was further developed with **better maintenance and expansion** of the existing water sources.

- **Restoration of Stone Spouts and Wells**: The Malla kings maintained and expanded ancient water sources, ensuring water availability in cities like Kathmandu, Bhaktapur, and Patan.
- **Public Water Reservoirs**: Large reservoirs were built for water storage and irrigation.
- **Religious and Cultural Influence**: Many water sources were linked to temples, as water was considered sacred in Hindu and Buddhist traditions.

These systems were **simple, gravity-based, and relied on natural springs and rainwater harvesting**.

### 3. Early Modern Water Supply Systems (19th - 20th Century)

During the **Rana regime (1846-1951)**, Nepal saw the introduction of **modern water supply systems**. The ruling elites prioritized **urban water supply**, particularly in Kathmandu.

- **Sundhara and Tindhara Water Systems**: These **golden spouts** in Kathmandu were developed under **Prime Minister Bir Shumsher** to provide fresh drinking water to residents.
- **First Piped Water System (1895)**: Introduced in Kathmandu, this system supplied water through underground pipes from natural sources.
- **Reservoirs and Water Treatment**: Small-scale reservoirs and basic filtration systems were introduced to improve water quality.

Although these projects **benefited the elites**, rural areas still depended on **traditional sources**.

**4. Modern Water Supply Systems (1950 - Present)**

- **1973: Nepal Water Supply Corporation (NWSC)** was established to regulate and manage urban water supply.
- **1980s-1990s: Rural Water Supply Projects** were launched to bring water access to remote villages.

- **2000s-Present: Melamchi Water Supply Project** – Nepal's largest water supply initiative to address Kathmandu's water crisis by diverting water from the **Melamchi River**.
- **Advancements in Groundwater and Rainwater Harvesting** to support areas facing water shortages.

## 1.4 Objectives of water supply system

- To supply safe, wholesome and potable water to the consumers in adequate quantity efficiently at low cost.
- To make water throughout the year.
- To provide reliable water supply
- To supply water to industries
- To supply water to commercial arenas
- To save time in fetching water
- To supply water to the domesticated animals

- To protect from waterborne diseases

The Main objectives of the water supply system are to achieve the following things:

**1. Proper Supply**

The primary and most essential goal of a water supply system is to supply a sufficient amount of water to satisfy the needs of various sectors, which include:

• Domestic Use: Consumption, cooking, bathing, and sanitation.

• Industrial Applications: Refrigeration, washing, and production processes.

• Agriculture: Irrigation and livestock production.

A properly designed system will account for sufficient water at all times, even at peak demand or drought. Population growth, urbanization, and seasonal fluctuations in water use must be taken into consideration when designing the system.

## 2. Quality Assurance

Water quality is as important as quantity. The system must be capable of ensuring that the water supplied is:

- Safe to drink: Virus-free, bacteria-free, and free from poisonous chemicals.
- Odorless and clear: Odorless and devoid of any visible impurities.
- Toxin-free chemicals: Free from heavy metals, pesticides, or industrial toxicants.

For the water to be of good quality, filtration, sedimentation, chlorination, and other treatments are required. Poor quality water is a serious health risk in the form of waterborne diseases (cholera, typhoid, dysentery) which affect millions of individuals worldwide.

## 3. Efficient Distribution

Water should be provided effectively to every corner, providing:

Equitable distribution: No section should be devoid of water while other sections are getting surplus water.

Proper pressure: Water should flow at the necessary pressure, either in low or high-altitude regions.

Minimum losses: Reducing wastage and leaks in pipes.

Good distribution requires an organized network of reservoirs, pumping stations, pipelines, and valves. Engineers should also take topography, population density, and expansion capacity into consideration when planning the system.

**4. Cost-Effectiveness**

A water supply system must be cost-effective for both the government and consumers. The determinants of cost-effectiveness include:

- Construction and maintenance expenses: Utilizing long-lasting materials and modern construction techniques to reduce expenses in the long term.
- Energy efficiency: Reducing electricity for treatment and pumping.
- Reducing water losses: Preventing theft and leakages to prevent economic loss.

A good system maximizes resources without affecting quality or reliability.

## 5. Sustainability

Sustainability is a big issue today. A water supply system should:

- Conserve water resources: Protecting rivers, lakes, and groundwater sources from over-extraction.
- Employ green treatment processes: No use of harmful chemicals to the environment.
- Encourage rainwater harvesting and recycling of wastewater: To minimize the use of fresh water resources.

Sustainable water management guarantees future generations a long-term supply of pure water.

## 6. Reliability and Resilience

A water supply system must be reliable and capable of performing in extreme conditions, such as:

- Disasters: Flood, earthquake, drought, or landslide should not interrupt water supply.
- Technical failures: Burst pipes, pump failure, or contamination events need to be resolved urgently.
- Emergency services: Hospitals, fire brigades, and industries need to be supplied with uninterrupted water.

To achieve resilience, engineers must use strong infrastructure, redundant systems, and advanced monitoring technologies to detect and fix problems early.

In summary, an efficaciously designed water supply system should:

- Provide sufficient and safe water supply.
- Ensure equitable and effective distribution.
- Be sustainable and cost-saving.
- Consistency at all times.

As civil engineers of the future, your work will play a critical role in designing and operating water supply systems that meet these objectives. A good water supply system directly impacts public health, economic development, and environmental sustainability.

# 1.5 Schematic diagram of typical water supply system

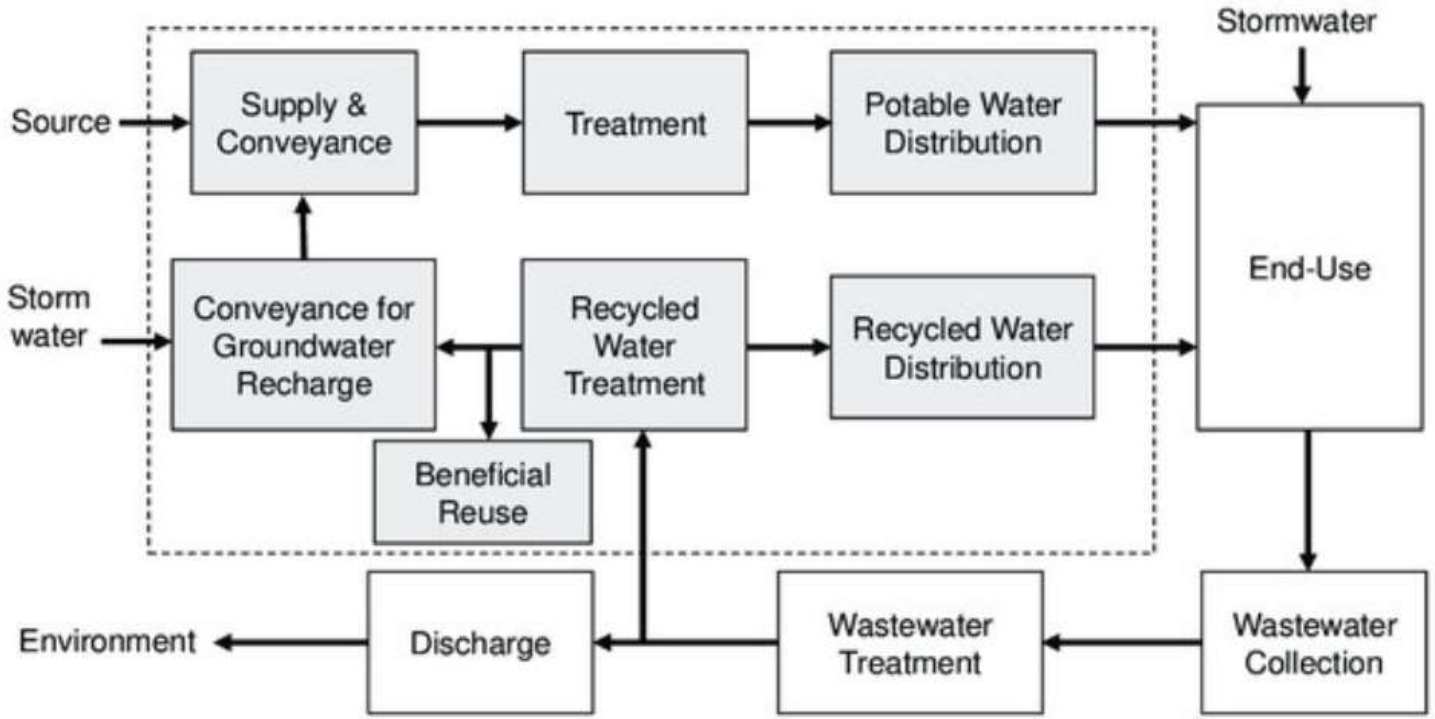


*Figure 4:Block diagram of the general components of a water supply system (Source: (Research gate , n.d.)*

**Explanation of the water supply system**

1. Water Source & Supply
   - The process starts with the Source, which can be rivers, lakes, reservoirs, or groundwater.
   - Water is transported through Supply & Conveyance systems such as pipelines and canals.
   - It then undergoes Treatment to remove impurities, making it safe for human consumption.

2. Distribution of Potable Water
   - After treatment, the Potable Water Distribution system ensures that clean and safe water reaches homes, industries, and other end-users.

3. End-Use & Wastewater Collection
   - Water is used for domestic, industrial, and agricultural purposes.
   - After usage, wastewater is collected through the Wastewater Collection system.
4. Wastewater Treatment & Discharge
   - Collected wastewater is sent to a Wastewater Treatment Plant, where harmful substances and pollutants are removed.
   - Treated wastewater can be discharged back into the environment or reused.
5. Water Recycling & Beneficial Reuse
   - Instead of discharging all treated water, some of it undergoes Recycled Water Treatment.
   - Recycled water is then distributed through the Recycled Water Distribution system.
   - Some water is used for groundwater recharge, which helps maintain underground water levels.
   - The Beneficial Reuse process ensures that treated wastewater is used for irrigation, industrial cooling, or other non-potable purposes.

6. Stormwater Management

- Stormwater is collected separately and can be used for groundwater recharge or directed to treatment plants.
- This process helps prevent flooding and ensures water conservation.

Conclusion

- This diagram represents a sustainable water management system, where water is treated, distributed, used, collected, and recycled.
- It ensures efficient use of water resources, reduces wastage, and promotes environmental sustainability.
- As civil engineers, understanding this system is essential for designing reliable and resilient water supply networks.

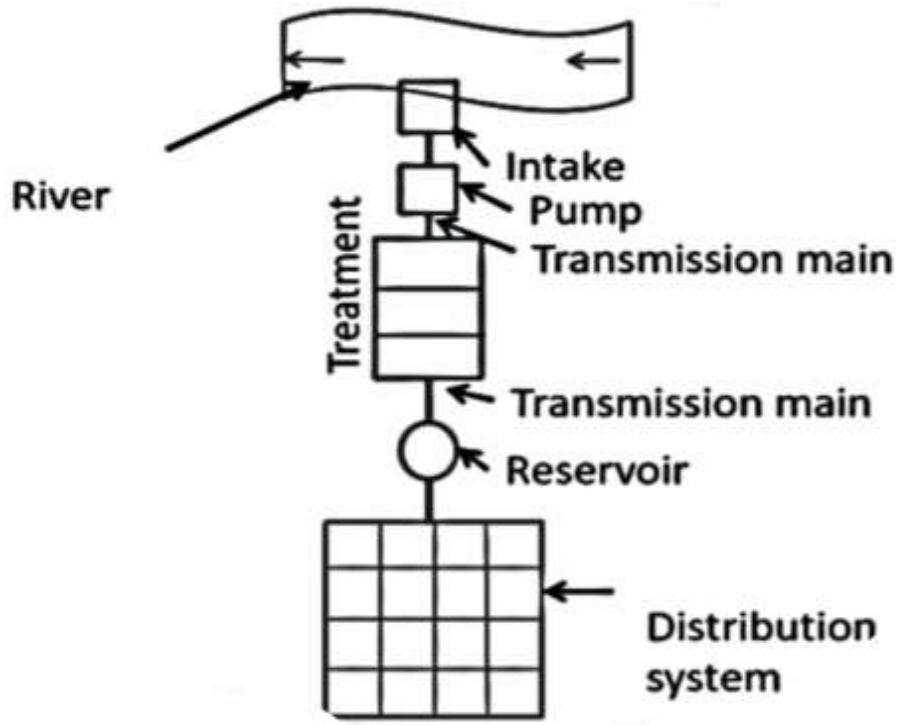


*Figure 5:Schematic diagram for water supply in urban area(Source: (Kansakar, 2015))*

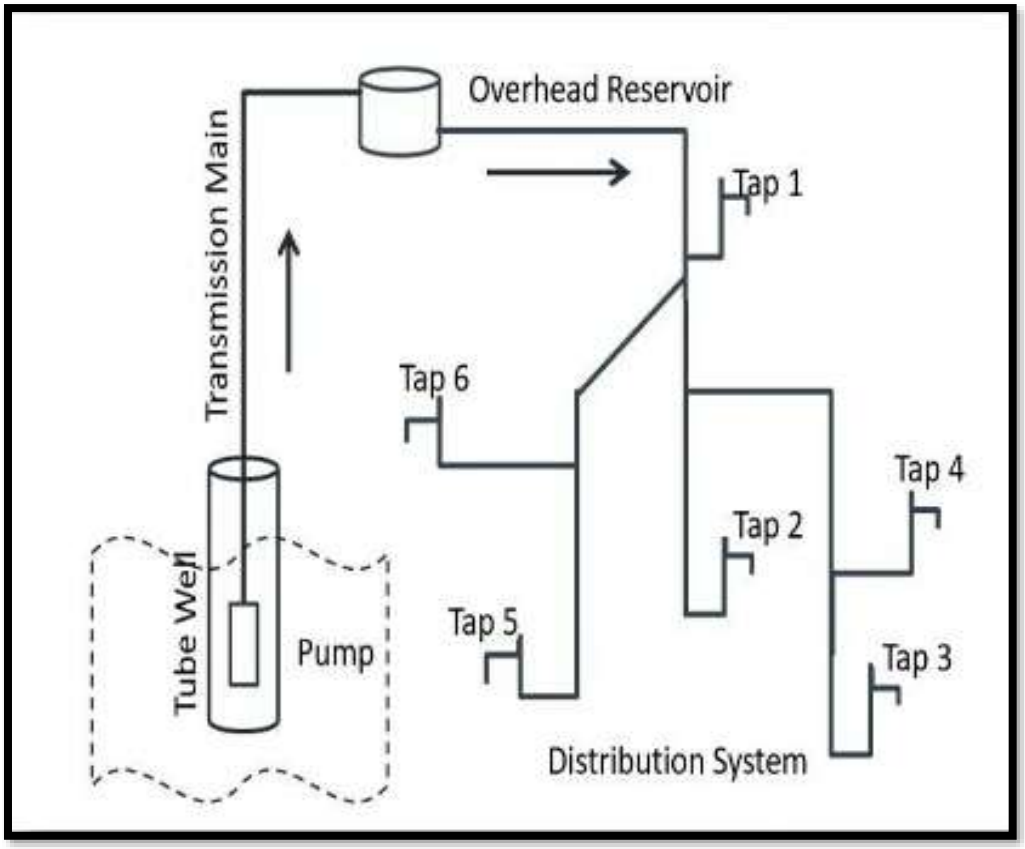


*Figure 6:Schematic diagram for water supply in Terai region (Source: (Kansakar, 2015))*

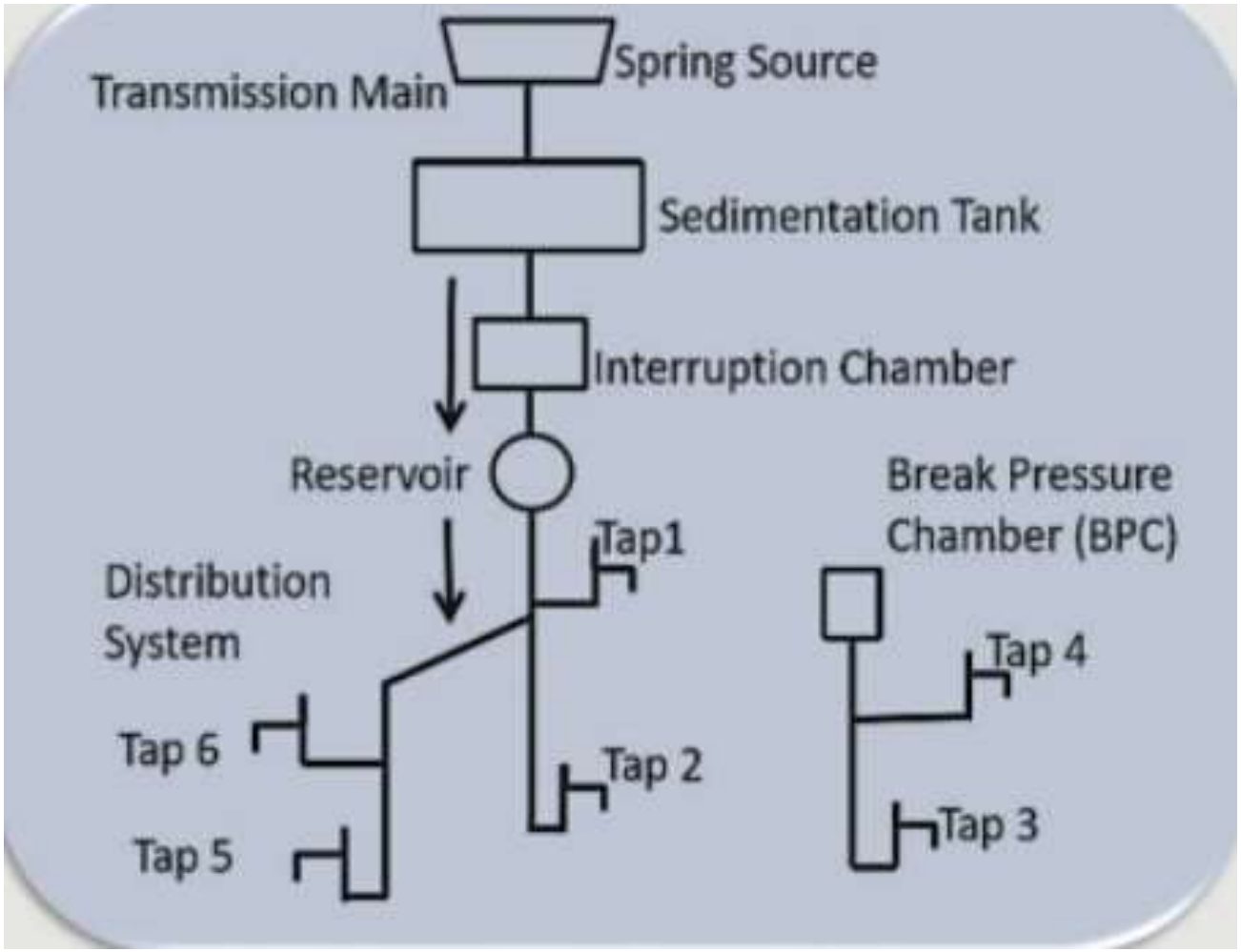


*Figure 7:Schematic diagram for water supply in hilly Region (Source: (Kansakar, 2015)*

## 1.6 Components of water supply system and their functions

Components having following functions:

- Collection
- Transmission
- Treatment
- Storage
- Distribution process

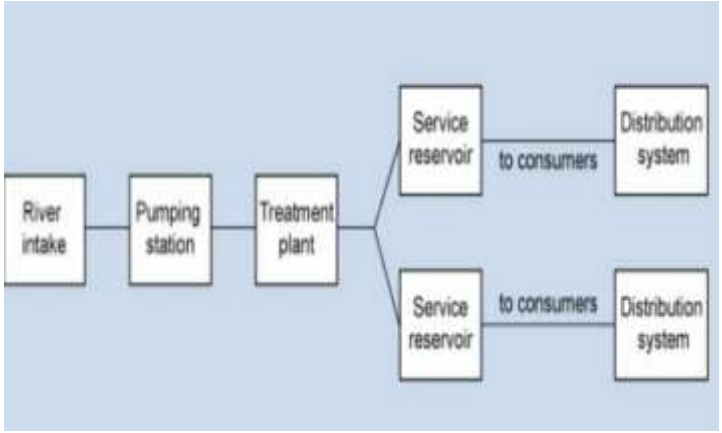


*Figure 8:Compopnent of Water supply System (source: (Research gate , n.d.)*

**The main component of the water supply system is:**

**1.Water Sources: Providing Raw Water for Supply**

a.Surface Water

b.Groundwater

c.Rainwater Harvesting

d.Water obtained from reclamation (Dr. B.C Punmia, 2013)

**2. Intake Structures**

• Ensure continuous and controlled water withdrawal.

• Prevent large debris, sediments, and aquatic life from entering the system.

• Reduce sedimentation and clogging in pipelines.

Examples include river intakes, reservoir intakes, and infiltration galleries.

## 3. Water Treatment Plant: Removing Impurities and Ensuring Safety

Water treatment plants are essential for purifying water to meet health and safety standards. Common treatment processes include:

- Coagulation and Flocculation
- Sedimentation
- Filtration
- Disinfection

## 4. Pumping Stations: Maintaining Pressure and Facilitating Water Movement.

## 5. Storage Tanks: Storing Treated Water for Demand Variations

## 6. Distribution Network: Delivering Water to Consumers

• Transmission Mains: Large pipes that transport water from treatment plants to storage facilities.
• Distribution Mains: Medium-sized pipes that branch from transmission mains to serve neighborhoods.

## 7. Control and Monitoring Systems: Regulating Flow, Pressure, and Quality

Modern water supply systems integrate control and monitoring systems for:
• Pressure Regulation – Preventing over-pressurization and pipe bursts.
• Leak Detection – Identifying and repairing leaks to reduce water loss.
• Water Quality Monitoring – Ensuring treated water remains safe for consumption.

## References


[1] Dr. B.C Punmia, E. K. (2013). *Water Supply Engineering.* New Delhi: Laxmi Publications (P) LTD.

[2]Kansakar, D. B. (2015). *water supply engineering.* kathmandu: Prakash Man Shakya.

[3](n.d.). Retrieved from Wikipedia: Purified water - Wikipedia

[4] *Research gate* . (n.d.). Retrieved from www.researchgate.com

[5] *Source: https://www.nrdc.org/stories/water-pollution-everything-you-need-know*. (n.d.).

# Thank You!!!